École Polytechnique Fédérale de Lausanne
Distributed Electrical Systems Laboratory
EPFL-STI-DESL-ELL, Station 11, CH-1015 Lausanne

http://desl-pwrs.epfl.ch

Student project proposal

Project title

Mechanical Modelling and Characterisation of a Reduced-Scale Hyperloop Pod for Levitation Control

Project type ☒ MSc thesis ☐ BA semester project ☒ MSc semester project

Project responsible and e-mail
Lucien Pierrejean – lucien.pierrejean@epfl.ch

Project description

The proposed project is part of the epfloop team's research into the electrification of transport, and more specifically into the propulsion and levitation of high-speed vehicles (referred to as pods) [1]. The pod is levitated by four electromagnetic levitation units, whose control requires accurate knowledge of the mechanical and electromagnetic behaviour of the pod. At present, several sources of uncertainty affect the successful levitation. The chassis has proven too flexible to be treated as a rigid body: its vibration modes may disturb or even cause instabilities of the pod's levitation controller. Finally, there is no reliable mechanical model of the pod, and the existing electromagnetic model of the levitation units has not been validated by measurements.

The goal of the project is to reduce these uncertainties and to provide the models needed to design the levitation controller, which will be used in a parallel student project. On the mechanical side, the project will be to determine the mass properties of the pod (mass, centre of mass, moments of inertia) and characterise the flexibility of the chassis, through both modelling and measurements. Based on these results, modifications to stiffen the chassis and to improve the stability of the static test bench will be proposed and implemented. On the electromagnetic side, the student will design and build a set-up to measure the static levitation force and use it to validate the existing model of the levitation units.

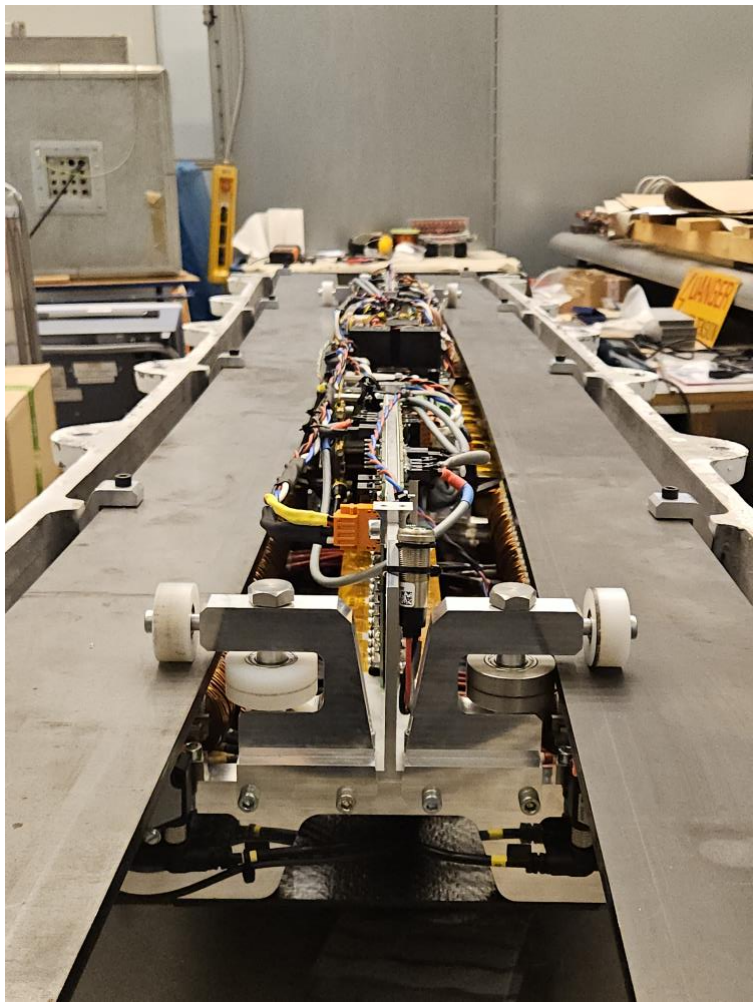
Tasks of the student

- Become familiar with the pod assembly, its chassis, the four levitation units and the static test bench.
- Develop a mechanical model of the pod:
  - Determine the mass, the centre of mass and the moments of inertia of the pod (from CAD and/or measurements).
  - Model the flexibility of the chassis (e.g. finite element analysis) and identify its main vibration modes.
  - Provide a model suitable for the design of the levitation controller (rigid-body dynamics and, if relevant, the dominant flexible modes).
- Propose and implement modifications to improve the rigidity of the chassis and verify the improvement by measurement.
- Identify the causes of the vibrations of the static test bench, propose and implement improvements, and verify them by measurement.
- Design and build a set-up to measure the static levitation force of a levitation unit as a function of the air gap and the current.
- Validate the existing electromagnetic model of the levitation units against the measurements.

Requirements

- Solid background in mechanics and structural dynamics (vibrations, modal analysis).
- Experience with CAD and finite element software (e.g. SolidWorks, ANSYS or Abaqus).
- Experience in the design and manufacturing of mechanical parts and test set-ups.
- Experience with mechanical measurements (accelerometers, force sensors, data acquisition) is a plus.
- Basic knowledge of electromagnetism is a plus.
- Interest in hands-on laboratory work on a real vehicle prototype.

This project offers the opportunity to combine mechanical modelling and design with hands-on experimentation on a real prototype.

Literature

[1] www.epfloop.ch